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Author(s): Leonard A. Brennan
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REGIONAL TESTS OF A MOUNTAIN QUAIL HABITAT MODEL

Leonard A. Brennan

ABSTRACT—A mountain quail (*Oreortyx pictus*) habitat model developed with data from northern California was tested using data from 750 plots measured at 16 sites in Idaho, Washington, Oregon, and Nevada. Accuracy of model output was assessed using habitat data from sites known to support mountain quail populations. In 15 out of 16 instances, the model accurately predicted that a test site represented mountain quail habitat. These tests represent one method for habitat model evaluation. Additional strategies for testing this data-based habitat model are discussed.

Modeling the habitat relationships of terrestrial vertebrates has become an established part of wildlife science during the past decade (Verner et al. 1986). Habitat models can be useful tools for resource managers only if the models are accurate. Therefore, models must be tested for accuracy with independent data if they are to be used as a basis for management decisions (Marcot et al. 1983). Although many habitat suitability index (HSI) models have been developed according to the U.S. Fish and Wildlife Service Habitat Evaluation Procedures (HEP) guidelines (Fish and Wildlife Service 1980, 1981) few have been tested for validity with independent data (Shamberger and O'Neil 1986).

The purpose of this paper is to present the results of regional tests of a mountain quail (*Oreortyx pictus*) HSI model. My objective was to test a previously developed mountain quail habitat model using data from regions within the geographic range of mountain quail that were different from the regions where the model was developed.

Study Area

Sixteen sites within six regions of four states were chosen for habitat data collection (Fig. 1, Table 1). A site was defined as the particular place where data collection occurred within a region. A region was defined as the general geographic area (*e.g.*, watershed or mountain range) that contained the particular survey sites. Each of the 16 sites represented a test of the model using data that were independent, in both time and space, from where the initial model was developed. These sites were chosen because they represented the habitats used by mountain quail in the extreme northeastern part of their geographic range where populations have been declining for several decades (Brennan 1990). Thus, the test sites most likely represent remnant areas of habitat in this part of the bird's geographic range. Vegetation was a mosaic of steppe, shrubs, and forest (Johnson and Simon 1987). Predominant land use practices were cattle grazing and timber production.

Methods

The HSI Model

The mountain quail HSI model used in this study was developed and tested previously with data collected from four regions of northern California using logistic regression (Brennan et al. 1986). Five variables (distance to water, distance to escape cover, percentage of shrub cover, maximum shrub height, and minimum shrub height) were the basis of the original model. This model differs from traditional HSI models because it was developed using a biometric approach, rather than qualitative natural history accounts. The form of the predictive equation corresponds to the general logistic regression model (Cox 1970:26) and is:

$$\text{HSI or } p(1\,|\,x) = \frac{e^{a+B_1X_{1i}+\ldots B_mX_{mi}}}{1 + e^{a+B_1X_{1i}+\ldots B_mX_{mi}}},$$

where $p(1\,|\,x)$ = the conditional probability that the area represents mountain quail habitat given a vector (x) of habitat measurements for the five habitat variables listed above; a = a constant; B_i =

TABLE 1. Descriptive statistics of 5 mountain quail habitat variables measured at 16 survey sites in eastern Oregon, southeastern Washington, western Idaho, and northern Nevada, during July and August 1989.

Region / Survey site[a]	Distance to water in meters[b]			Distance to escape cover[c]			Percent shrub cover[d]			Maximum shrub height in meters[e]			Minimum shrub height in meters[f]		
	x̄	SD	Range	x̄	SD	Range	x̄	SD	Range	x̄	SD	Range	x̄	SD	Range
Imnaha River, Oregon															
A. Lower Bear Gulch	43.7	33.2	0–120	1.6	2.0	0–10	61.6	28.7	5–100	4.5	1.7	1.0–7.0	0.78	0.53	0.1–2.0
B. Horse Creek	33.4	18.3	0–70	1.6	1.6	0–5	57.2	29.2	10–100	4.5	1.5	2.0–7.0	0.75	0.31	0.2–1.5
Southeast Washington															
C. Joseph Creek	59.9	36.8	3–150	2.5	2.0	0–10	56.1	28.4	10–100	4.0	1.9	1.5–9.9	0.52	0.34	0.1–2.0
D. Tumalum Creek	55.8	30.9	15–120	2.2	2.5	0–10	56.2	33.3	10–100	4.0	1.9	0.5–7.0	0.63	0.31	0.2–1.0
Snake River, Idaho															
E. Kurry Creek–Pittsburg Landing	32.9	14.6	10–75	3.5	3.6	0–10	40.6	28.8	0–100	4.0	2.6	0.0–8.0	0.53	0.48	0.0–2.0
Salmon River, Idaho															
F. Eagle Creek	43.6	41.1	0–200	1.3	1.5	0–5	77.4	29.3	10–100	4.6	2.1	1.0–7.0	1.03	0.77	0.1–3.0
G. Rocky Canyon	66.4	55.1	5–250	1.4	1.6	0–5	75.4	23.9	10–100	3.6	1.8	1.0–7.0	0.37	0.26	0.1–1.2
H. Pine Bar	67.0	45.5	5–200	1.6	1.5	0–5	61.6	25.0	10–100	3.7	1.6	1.0–6.0	0.50	0.35	0.1–1.5
I. White Bird Creek	26.8	21.4	1–75	4.1	3.9	0–15	69.5	18.6	25–100	5.9	1.4	2.0–7.5	1.37	0.48	0.4–2.2
J. Skookumchuck Creek	83.2	62.5	5–250	1.3	1.5	0–5	74.7	26.3	10–100	3.9	2.0	1.0–7.0	0.58	0.44	0.1–2.0
K. Allison Creek	47.0	58.7	0–300	1.4	1.4	0–6	78.3	19.7	30–100	4.5	1.8	1.0–8.0	0.97	0.85	0.1–4.0
L. Pollock	34.4	23.9	0–90	1.4	1.7	0–6	75.1	18.0	20–100	4.3	2.0	1.0–8.0	0.92	0.54	0.3–2.5
M. Ranyhan Gulch	38.8	27.9	0–110	0.9	1.6	0–7	74.9	25.7	10–100	4.4	2.1	1.0–9.9	0.85	0.70	0.1–3.0
N. Rapid River	37.2	21.4	0–80	2.2	1.7	0–5	68.8	29.3	20–100	5.4	1.4	2.0–7.0	0.96	0.57	0.3–3.0
Boise District, Idaho															
O. Syrup Creek	16.3	12.4	0–50	5.4	6.0	0–25	51.5	34.9	0–100	4.5	2.5	0.1–8.0	0.47	0.21	0.1–1.0
Santa Rosa Mountains, Nevada															
P. Porcupine Creek	52.1	36.1	0–150	13.9	10.5	0–35	30.3	19.6	5–80	1.4	0.8	0.2–4.0	0.37	0.30	0.1–1.5

[a] Values based on 25 habitat plots for White Bird Creek, Rocky Canyon, Pine Bar, and Rapid River; 50 habitat plots for all other sites.
[b] Distances were measured from the center of each habitat plot to the nearest visible free surface water.
[c] Distance to escape cover was measured from the center of each plot to the nearest place a quail could use to evade a predator (e.g., dense clump of vegetation, rock crevice, etc.).
[d] Percentage of shrub cover was measured as the percentage of a 15 m tape passing through plot center that was intercepted by shrubs.
[e] Maximum shrub height was defined as the height of the tallest living shrub within the 0.02 ha habitat plot.
[f] Minimum shrub height was defined as the height of the shortest living shrub within the 0.02 ha circular habitat plot.
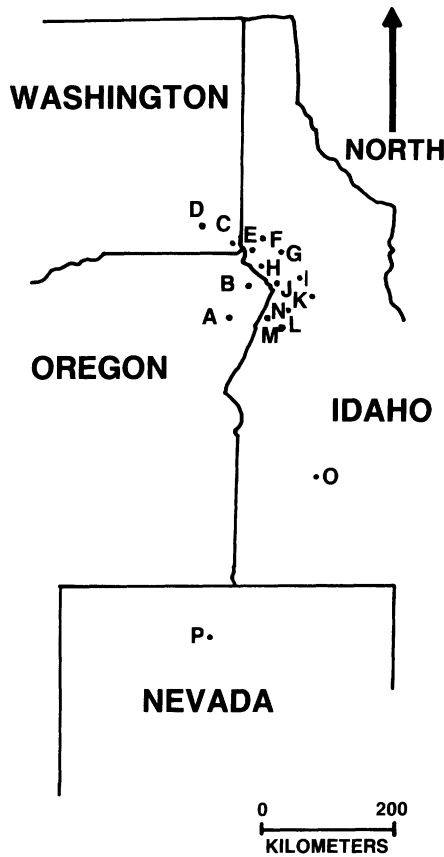
FIGURE 1.   Geographic distribution of the mountain quail habitat survey sites. Letters correspond to names of sites listed in Table 1.

the regression coefficients; and X_i values of predictor (habitat) variables in the model. Actual values of the constant and regression coefficients are given in the computer program listed in Appendix 1. Cox (1970) provides a complete description of logistic regression computation methods. This kind of model output can be used within the HEP system because the conditional probabilities, like traditional HSI values, are scaled between 0 (poor habitat) and 1 (good habitat). Approaching an HSI analysis from a probabilistic standpoint allows the investigator to consider model assumptions from a perspective that is different from the traditional HSI modeling approach.

Data Collection and Analysis

Data were collected during July and August 1989. All sampling was conducted within creekside brush and riparian plant communities because other habitats, such as annual grasslands, are not used by mountain quail (Ormiston 1966; Gutiérrez 1980). After a site was chosen, a random starting point, random azimuth and random distance (between 50 and 100 m) were chosen. Habitat plots (0.02 ha, 15-m diameter) were systematically placed at 50 m intervals along the random azimuth. If a transect intersected a different habitat type (*e.g.*, annual grassland), a new random azimuth and distance were chosen and sampling resumed. Sampling continued until at least 25 plots were measured; 50 plots were measured at most sites. A total of 750 habitat plots were measured over 16 sites. Descriptive statistics and HSI values were calculated using the program in Appendix 1, and the SPSS PC+ software package (Norušis 1986). Coefficients used in the logistic regression equation in Appendix 1 are from Brennan (1986). Skewness values (g_1; Zar 1974:72) were used to test the symmetry (and hence normality) of the distributions of the HSI scores.

Model test criteria used by Brennan et al. (1986) were used in this study. Because habitat data were collected from areas known to support mountain quail populations, I considered model output accurate if the mean HSI value from a site was greater than 0.5 (e.g., prediction of a greater than random probability that the area represented mountain quail habitat).

RESULTS

Mountain quail habitat at the study sites was characterized by short distances to water and escape cover and tall, dense shrubs (Table 1). The mountain quail HSI model predicted that 15 of 16 sites represented mountain quail habitat (Fig. 2). Only the Porcupine Creek data (Fig. 2P) had HSI values skewed toward the low end of the HSI scale ($\bar{x} <$ 0.5), and were thus not classified as mountain quail habitat. The distributions of all HSI scores had g statistics with absolute values that were significantly greater than zero ($p < 0.05$; based on critical values of g_1 in Zar 1974:500). The significant skewness of the HSI values from all sites indicated that the HSI values were not distributed normally. With the exception of the HSI values from Porcupine Creek (Fig. 2P), which had significant ($p < 0.05$) positive skewness, HSI values from each site had distributions with significant ($p < 0.05$) negative skewness.

Of the 16 sites surveyed, 8 (Horse Creek [Fig. 2B], Eagle Creek [Fig. 2F], Rocky Canyon [Fig. 2G], Pine Bar [Fig. 2H], Skookumchuck Creek [Fig. 2J], Allison Creek [Fig. 2K], Pollock [Fig. 2L], and Rapid River [Fig. 2N]) had a low-end range on the HSI scale of >0.4. Kurry Creek-Pittsburg Landing (Fig. 2E), Syrup Creek (Fig. 2O), and Porcupine Creek (Fig. 2P) had the widest range of HSI scores and the largest relative amounts of poor quality (based on low HSI scores) habitat. These HSI values were a function of the ranges of the habitat structure at these areas being greater than the other sites (Table 1). For example, the distance to escape cover at Syrup Creek had a maximum of 35 m whereas 10–15 m were the maximum values observed at the other sites (Table 1).

DISCUSSION

The assumption that HSI values, or other measures of habitat quality, are positively correlated with population density may be erroneous (Van Horne 1983). Therefore, I chose to test whether the mountain quail habitat model developed with data from California would provide accurate predictions using data from other areas occupied by mountain quail. Basing HSI values on conditional probabilities that are related to particular aspects of habitat structure allows an investigator to forego the positive density assumption in an HSI context. This can be done because the area is being assessed from the standpoint of the *probability* that it represents habitat of a particular species. Although this may initially seem like a minor point of semantics, it has an important implication when HSI values are considered from the standpoint of conditional probabilities. When a species is present in a particular habitat (regardless of the population density), a valid HSI model should predict a relatively high (e.g., >0.5) probability of the area representing the habitat of a particular species. This was certainly the case with the results from this study. Other methods of model evaluation, such as testing with data from areas that do not support mountain quail populations, or performing sensitivity analyses using computer simulation, must be done before this model can be considered valid (Marcot et al. 1983).

The model developed by Brennan et al. (1986) was designed to assess mountain quail habitat from a *structural* perspective. Floristic components were not included during model development because the goal was to build a general model that could be used in a variety of situations over a broad geographic area. Furthermore, virtually all shrubs at the areas in California used for model development provided food resources for mountain quail (Brennan et al. 1987). Thus, a key assumption of this mountain quail model, from the standpoint of both development and application, is that structural aspects of the habitat (such as percentage of shrub cover or shrub height) are correlated with
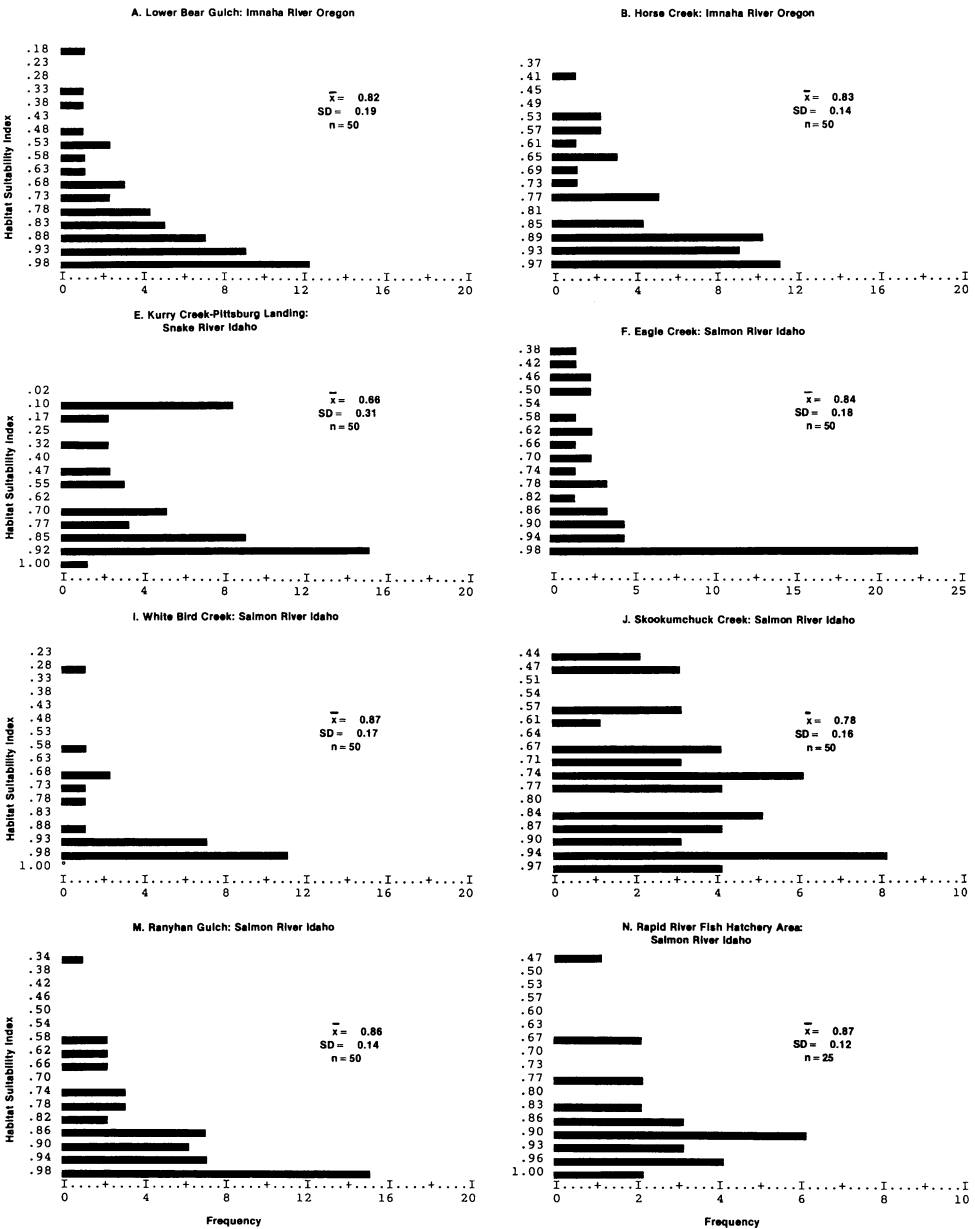
FIGURE 2.   HSI model output using mountain quail habitat data collected during July and August 1989 from 750 habitat plots at 16 sites in Idaho, Oregon, Nevada, and Washington. Each sample within a particular site represents the mountain quail HSI values calculated by the program in Appendix 1 using distance to water, distance to cover, percentage of shrub cover, maximum shrub

the availability of food resources (*i.e.,* the greater amount of shrub cover or shrub height, the more available food resources, and hence the better quality habitat). In California, and in the habitats of the Imnaha River, southeast Washington, and Salmon River regions, this is a reasonable assumption because the majority of the cover-producing shrubs also
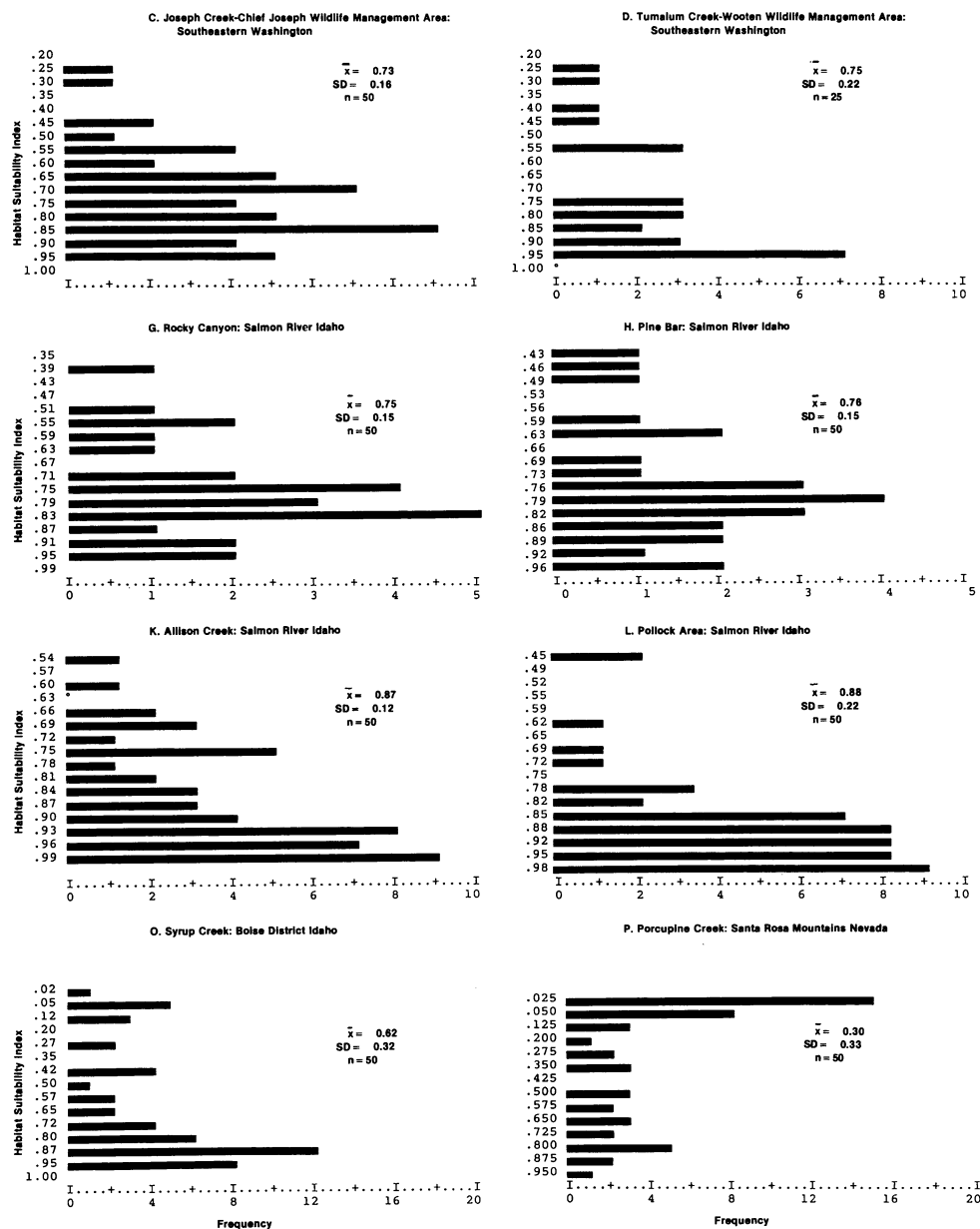
height, minimum shrub height values measured on one 0.02 ha habitat plot. Values given are arithmetic mean, one standard deviation, and the number of habitat plots measured at a particular site. Descriptive statistics of habitat data used for the HSI calculations are given in Table 1.

provide foods eaten by mountain quail. At the Syrup Creek site, however, this led to inflated HSI values because the majority of the shrubs present (*e.g.,* willows [*Salix* spp.]) do not provide food resources for mountain quail. When the Syrup Creek HSI value was recalculated using only food-producing shrubs, the mean HSI score was lowered from

0.62 to 0.52, a 16% reduction. Recalculating scores for the other 15 sites using only food-producing shrubs lowered HSI values only 1–2%. Thus, in areas where the majority of shrub cover consists of willows, or other non-food producing shrubs, it might be best to constrain the percent shrub cover values to the food-producing species that are present. Even though the mountain quail is the least-studied of North American quail, their food habits are fairly well-known (Yocum and Harris 1953; Ormiston 1966; Gutiérrez 1980). Thus, knowing which species of perennial shrubs provide food resources for mountain quail in a particular area can be used to good advantage when the HSI model is used in a habitat survey. Constraining the percent shrub cover values to only the food-producing species would serve to provide a more conservative (e.g., less likely to be positively biased) and hence more accurate HSI assessment for mountain quail, which in turn would provide a more accurate representation of habitat quality for this quail.

SUMMARY AND RECOMMENDATIONS

Application of a mountain quail habitat model developed with data from northern California provided accurate results when tested with habitat data from the eastern, arid-land portion of this bird's geographic range. This study provides one example of the scale and extent at which HSI models should be tested with independent data. Further tests and sensitivity analyses are required before this model can be implemented throughout the entire range of this quail. Most of the model output values had highly-skewed distributions that deviated significantly from normality. The distribution of HSI scores from a particular site should be considered before further statistical analyses, such as testing for differences in HSI values between sites, are conducted. If HSI scores have highly skewed distributions, then further statistical analyses and tests should be conducted using non-parametric statistics. Although the mountain quail model tested here represents a general structural habitat model, results from this study indicated that HSI values may be inflated (i.e., positively biased) if percent cover values from non-food producing shrubs are included in the model. The next step in testing this HSI model is to collect data from mountain quail habitat in the desert ranges of southern California and Baja California Norte, and areas of the southern Sierra Nevada and southern California Coast Range, and evaluate model output. Results from further tests using data from these areas could determine whether this model should be applied to situations throughout the entire range of mountain quail.

ACKNOWLEDGMENTS

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Department of Wildlife and Fisheries, P.O. Drawer LW, Mississippi State University, MS 39762.

APPENDIX 1.   Computer command program used to calculate descriptive statistics and habitat suitability index values for data collected from a survey of mountain quail habitats in eastern Oregon, southeastern Washington, western Idaho, and northern Nevada during August 1989. Compute command in lines 4–5 based on a logistic regression model derived from mountain quail habitat measurements from northern California (see Brennan et al. 1986). Software used for all analyses was SPSS PC+ (Norusis 1986).

```
TITLE "MOUNTAIN QUAIL HSI: SYRUP CREEK BOISE DISTRICT".
DATA LIST FILE = 'SYRUPCRK.DAT' FREE
/WT CV SR MX MN.
COMPUTE HSI = EXP(0.55+(−0.005*WT)+(−0.259*CV)+(1.94*MN)+(0.04*MX)+(.007*SR))/
  (1+(EXP(0.55+(−0.005*WT)+(−0.259*CV)+(1.94*MN)+(0.04*MX)+(0.007*SR)))).
WRITE HSI.
VARIABLE LABELS WT 'DISTANCE TO WATER'
/CV 'DISTANCE TO ESCAPE COVER'
/SR 'PERCENT SHRUB COVER'
/MX 'MAXIMUM SHRUB HEIGHT'
/MN 'MINIMUM SHRUB HEIGHT'
/HSI 'HABITAT SUITABILITY INDEX'.
FREQUENCIES VARIABLES = HSI WT CV SR MX MN
/FORMAT = NOTABLE
/STATISTICS = ALL
/HISTOGRAM.
LIST VARIABLES = HSI.
```